Title of the Invention

Process and Apparatus for Manufacturing Isotropic Nonwovens

Field of the Invention

The invention relates to a process for manufacturing of a nonwoven, which shows almost the same tensile strength and elongation properties in longitudinal direction (machine direction, MD) and cross direction (CD) (a so-called isotropic nonwoven), as well as to a corresponding production line.

Description of the Prior Art

It is generally known that, due to the fact that in the web formation process and in particular in the common carding process fibers mainly orient themselves in longitudinal direction, nonwovens show a higher strength and a lower elasticity in the laid longitudinal fiber direction in comparison to the corresponding values in the direction which is at right angles to the preferred fiber orientation. This difference in CD/MD strength can be observed in all nonwovens independent of their type of bonding, i.e. this difference not only occurs with thermally bonded but also with mechanically bonded nonwovens e.g. needle-punched webs or even stitch-bonded nonwovens,

whereas in the latter, the fibers are at least stitch-bonded on one side of the nonwoven.

Attempts have already been made to counteract a longitudinal orientation of the fibers during the web formation process, but after all with only little effect. The reorientation of the fibers in cross direction, which can be achieved during the web formation process, is only modest with regard to the angle and/or the portion of the fibers oriented crosswise in relation to the total mass of fibers. Frequently, crimped fibers are used or the fibers are compressed when the web is taken off from the card, which increases the elasticity in machine direction but only results in a slight increase of the CD strength.

Different proposals relate to the possibility of eliminating or at least decreasing the stated anisotropy of the web, which results from the production process, later in the bonding process. In connection with stitch-bonded nonwovens, some of these proposals relate to a special stitch bonding technique, which shall result in a higher CD strength (cf. the patent specifications oft the former DDR [German Democratic Republic] DD 283,169 A5; DD 283,171 A5; DD 288,634 A5). Another approach of improving the CD strength is to insert cross threads during the bonding process, in particular during the stitch-bonding process, and to integrate these cross threads in the nonwoven

(cf. DD 285,383 A5). But by means of the processes mentioned here, the CD strength of a nonwoven can only be improved to an insufficient degree.

In the field of nonwoven production, in particular of needle-punched webs, it is a custom to transform a web with moderate width coming from a card by laying it in a zigzag in cross direction to form a new web length with a higher width and a higher fiber mass per surface unit, and to mechanically bond this new web length for example by needling (cf. for example the German book publication "Vliesstoffe - Rohstoffe, Herstellung, Anwendung, Eigenschaften, Prüfung", edited by W. Albrecht, H. Fuchs, W. Kittelmann, Wiley-VCH, Weinheim, 2000, ISBN 3-527-29535-6, page 158, "Aufgaben des Vlieslegers"; this book is cited several times hereinafter with different chapters). Within the web length formed by laying a fleece in zigzag, the main part of the fibers is oriented at right angles to the running direction of this web length. As a result, the CD strength is higher than the MD strength, so in principle, the difference persists, although just the other way round.

Therefore, one has proceeded to draft these cross-laid zigzag webs before entering the needling process, so that the fibers are brought from a cross orientation into an orientation which is at an angle to the edge of the web (under a preferred angle α). Namely, when a web is drafted the fibers of which are

oriented crosswise, about half of the fibers orient themselves at an angle $+\alpha$ and the other half of the fibers at an angle $-\alpha$. Thus, the fibers in the web cross themselves (cf. the above mentioned book publication "Vliesstoffe", page 165 f about web drafting). Such a drafting process can provide for an approximation of the strength values in machine and in cross direction and serve to eliminate the anisotropy for the most part. Besides, this type of web formation in principle also allows for other bonding processes besides needling. The disadvantage, however, is that the directions which show the highest strength are not those directions which are lying in parallel or at right angles to the side edges of the web length, but lying under the said angle $\pm\alpha$. To be able to use the strength of the web length in an optimal way, for fabrication the parts would have to be cut out of the web length at an angle (the angle α). For financial reasons, this method only used in exceptional cases because of the resulting triangular waste parts which cannot be used.

Another proposal which also relates to the field of stitch bonding technology (cf. German Offenlegungsschrift DE 198 43 078 A1) for the formation of an almost isotropic bulky stitch-bonded nonwoven with a high portion of standing fibers consists of preparing a thicker web of any width by laying a uniform fiber fleece in zigzag the fibers of which are

mainly oriented lengthwise. As the fibers of this thicker web are oriented at right angles to its longitudinal direction, the web shows a higher strength in the cross direction. The subsequent treatment of this web is effected at right angles to the working direction of the web forming machine of the primary fleece and at right angles to the orientation of the fibers. By mechanically bonding this web using the stitch bonding technique on at least either the top or the bottom side, the MD strength is increased, because in the stitch bonding process many fibers are reoriented into the working direction of the stitch bonding process. Thus, the stitch bonding technique can provide for an improvement of the poor MD strength of the web laid in zigzag and for a reduction of the inequality. By this procedure, however, a complete balance of MD/CD strength can only be achieved to a limited degree. This is because the approximation of the strength properties in machine and cross direction depends on the fiber mass of the web per surface unit and on the portion of the fibers which can be oriented lengthwise by using the stitch bonding technique, i.e. the degree of stitch bonding. By the way, this web formation process is bound to the mechanical bonding of the web by means of the stitch-bonding technique.

Another proposal also relating to the field of stitch-bonded nonwovens according to the patent specification of the

former DDR (German Democratic Republic) with the number DD 292,489 A5 uses several fiber layers in the web with fibers of different orientations, which are lying in parallel and/or crosswise to the edge of the web length and are crossing each other. In the process presented in said publication, the fiber web is composed of two separate layers, one of which consists of mainly lengthwise oriented fibers and the other consists of mainly crosswise oriented fibers. In this process, the individual fiber layers are first produced by separate web forming devices and after bringing together the two layers, the common web is subject to a mechanical web bonding process using the stitch bonding technique. With these double-layer webs, isotropic stitch-bonded nonwovens with a high portion of standing fibers can be produced. The disadvantage of this process is, however, that two separate web forming devices are needed. Because of the considerable investment costs which are necessary, the production costs per surface unit for the final product are extremely high, so that the produced stitch-bonded nonwovens perhaps can be no longer offered on the market at a competitive price.

It is known that for the formation of nonwovens several fleeces are united to form one web in order to homogenize the local density over the surface of a nonwoven with the aid of at least one web forming device with two web doffing devices or

several web forming devices placed in line one after the other (cf. the said book publication "Vliesstoffe", page 157 f about web formation). Here, in at least one web forming process or in several web forming processes taking place simultaneously, the same raw fibers and/or the same blend of raw fibers are used to produce at least two separate fleeces of the same width, which are guided over different ways and afterwards are guided at the same speed and in the same direction as well as with the same positioning in cross direction to be reunited to a common web. Because of the layer structure of the web resulting from the use of several fleeces, any local differences in density are compensated for to a great extent. Afterwards, the web produced in such a way is bonded to form a nonwoven by using any bonding method. But with this technique, the MD/CD strength ratio cannot be influenced to a considerable degree.

Summary of the Invention

It is an object of the invention to present a process and a device for the formation of a nonwoven which is to a great extent isotropic in machine and in cross direction, the maximum strength values are achieved in parallel and/or at right angles to the lateral edge of the web length. Another object of the invention consists therein that such a nonwoven can be produced at low investment cost and which can be bonded using any bonding process.

According to the invention these objects are achieved thereby that a double-layer web is produced on a single web forming device, one layer of fibers is composed of mainly lengthwise oriented fibers and the other fiber layer laid in zigzag contains mainly crosswise oriented fibers. The fiber layer laid in zigzag is redirected and brought together with the other fiber layer. This double-layer web, which is to a great extent isotropic and which has been produced at low cost, can afterwards be bonded by any bonding technique to form a nonwoven.

Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction in with the accompanying drawings.

Brief Description of the Drawings

Figure 1 shows a perspective drawing of a double-layer web for the formation of a nonwoven, which is composed of a lower web layer with lengthwise oriented fibers and of an upper partial web with crosswise oriented fibers,

Figure 2 is a perspective drawing of a three-layer web with a medium partial web with crosswise oriented fibers and an upper and a lower web layer with lengthwise oriented fibers,

Figure 3 shows a first embodiment of a device for the formation of a multilayer isotropic nonwoven. Here, the working direction of the web formation device and the device for bonding the nonwoven are in true alignment, but in the course of the faster or cross-fiber partial web a double redirection by 90° compensating itself takes place, i.e. first a mere redirection of the faster partial web to the cross direction and then a redirection by 90° immanent to the process by laying in zigzag the faster partial web to form the cross-fiber partial web,

Figure 4 contains a second embodiment of a device for the formation of a multilayer isotropic web where the working direction for the web formation and for the subsequent treatment of the complete web also are in alignment. In the course of the faster or cross-fiber partial web, also a double redirection by 90° compensating itself takes place, but in this case, the faster partial web is laid in zigzag to form the cross-fiber partial web under a first redirection by 90° and afterwards another redirection of this web back to its original direction,

Figure 5 shows a third embodiment of a device for the formation of a multilayer isotropic web, where the working direction for the web formation on the one hand and the device for the bonding of the web on the other hand are arranged at right angles to each other and where not only in the course of the slower partial web but also in the course of the cross-

fiber partial web a redirection by 90° takes place. For the cross-fiber partial web, this redirection results from laying the web in zigzag and for the slower partial web, the redirection was necessary in order to guarantee that the web runs in the same direction and has the same position in cross direction,

Figure 6 is a separate perspective drawing of a space-saving web redirecting device.

Detailed Description of the Drawings

The subject matter of the invention to be discussed on the basis of different embodiments is a device and a process for the formation of a multilayer isotropic nonwoven, which is mechanically bonded at least on either the top or the bottom side using any kind of bonding method, but preferably by stitch-bonding the surface-near fibers, and where at least one layer in the web is composed of cross-oriented fibers. The nonwoven, which according to the invention can be produced at low investment cost, shall be to a great extent isotropic in machine and cross direction, and the maximal strength values shall be achieved in parallel and/or at right angles to the lateral side of the web length.

According to the invention, with the process and/or the respective production line a multilayer web produced at low cost shall be delivered to the subsequent web bonding process. The multilayer complete web 4 which shall be bonded to form a nonwoven, is composed of at least one partial web 5 with mainly lengthwise oriented fibers 3' and another, cross-fiber partial web 1 which is produced by laying the fleece in zigzag and the fibers of which are mainly oriented crosswise 3, as shown in perspective in figure 1 for a double-layer web. In this process, it is not essential, whether the cross oriented partial web 1 or the lenthwise oriented partial web 5 is situated at the top or at the bottom of the complete web 4. This is more important for the used bonding method and the subsequent use of the nonwoven. Moreover, both partial webs have to a great extent the same surface weight. In a specific case, the distribution of the fiber quantities among the two partial webs 1 and 5 will be chosen empirically depending on the used bonding method and the intended use of the nonwoven.

Figure 2 contains a perspective drawing of a three-layer web 6, which at the bottom and at the top is composed of a „straight" partial web 5' and/or 5'' with mainly lengthwise oriented fibers 3', whereas the cross-fiber partial web 1'' placed between these two webs contains mainly crosswise oriented fibers 3'. For the three-layer structure of the web, it is essential that the cross-fiber partial web 1'' is situated in the middle.

The further explanations only relate to the cost-effective and rational production of a double-layer web 4. The devices for the formation of such a nonwoven in the different embodiments described in the figures 3, 4 and 5 generally contain the following components:

First, a device for the dry web formation has to be provided, which in principle can be of any design, but with the restriction that only those web formation devices are taken into consideration which allow for simultaneous and locally displaced doffing of at least two webs or fleeces and which also allow for considerable differences in speed when doffing the webs. With regard to the web formation processes, in particular the above mentioned book publication "Vliesstoffe - Rohstoffe, Herstellung, Anwendung, Eigenschaften, Prüfung", edited by W. Albrecht, H. Fuchs, W. Kittelmann, Wiley-VCH, Weinheim, 2000, ISBN 3-527-29535-6 shall be referred to. In chapter 4 „Trockenverfahren" (page 137 to 228), this textbook deals with the different processes for the dry web formation and in subchapter 4.1.2 „Faservliese nach dem Kardierverfahren", in particular the pages 145 to 157 deal with individual aspects of the process and machine technology of web formation on cards. To the knowledge of the applicant, only cards or carding machines provide several doffers, which moreover can be driven at highly different speeds if the wires on the doffers are equipped accordingly. For this reason, the embodiment in figure 3 outlines a web forming card 10.

The web forming card 10 is equipped with two doffers 11 and 12 staggered in height. Because of the corresponding equipment of its wires, one doffer 11 outlined at the bottom in figure 3 is designed in such a way that it allows for a much higher doffing speed v_2 when doffing the partial web 2 than the other doffer 12 shown at the top in figure 3. At this doffer, the doffing speed is only v_1. The relation v_1/v_2 of the two doffing speeds will be dealt with below in more detail. At this point it shall only be mentioned that if per unit of time, at the two doffers a fiber mass of almost the same size is doffed, the surface weight of the fleece doffed at the lower, faster doffer 11 is in compliance with the speed ratio more lightweight than the slower fleece 5 doffed at the other doffer 12. But by laying the faster partial web in zigzag to form a slower cross-fiber partial web 1, the surface weight of this web is increased again in compliance with the speed ratio v_1/v_2.

In the sequel of the explanations, the abridged terms „faster web doffer 11", „faster partial web 2", „slower web doffer 12" and "slower partial web 5" are used.

As to the fiber mass actually taken off in a real case at the web doffers 11 and 12 and/or the mass ratio, this is above all dependent on the bonding method and on the intended use of the nonwoven to be produced. If the nonwoven is to be stitch-bonded, it is quite useful for the slower partial web 5 with lengthwise oriented fibers to have a considerably smaller share

in the fiber mass (e. g. 35 percent in weight) compared to the faster partial web 2 the fibers of which later will be oriented crosswise (e. g. 65 percent in weight), because the portion of fibers oriented lengthwise will be increased again by the bonding stitches and/or the stitch wales. In general it can be said, that the web forming device takes a fiber mass of approximately the same size per unit of time for the faster partial web 2 as for the slower partial web 5, whereas this is a rough approximation which allows for a difference of ± 20 percent in weight. Thus, the range of mass distribution can extend from about 30:70 to 70:30.

In all variants of the invention shown in figures 3, 4 and 5, the faster partial web 2 is assigned at least indirectly a web laying device 14, 22 or 45 respectively, which provide for laying the faster partial web 2 in zigzag to form the cross-fiber partial web 1. The partial web is in each case led to the web laying device by means of transport belts, which is, however, not shown in the simplified basic type of drawing of the figures 3 and 5. In the embodiment in figure 4, the transport belt 21 is shown which serves to feed the faster partial web 2 to the web laying device 22. By laying the faster partial web 2 in zigzag, a cross-fiber partial web 1 is produced, which consists of fibers 3 mainly oriented at right angles to the longitudinal direction of the web length. By laying the faster partial web 2 in zigzag to form a cross-fiber web 1, its running speed is decreased and at the same time, its surface

weight is increased accordingly. In connection with the laying of webs in zigzag it must also be referred to the above mentioned textbook „Vliesstoffe", which in subchapter 4.1.2.3 „Vliesbildung" (pages 157 - 165) deals with the process and machine specific aspects of the cross-lapping or zigzag laying of fleeces in particular to form cross-oriented webs. Here it is differentiated between different designs of web laying devices, inter alia steep arm lappers (Camelback) and horizontal lappers. To simplify matters, in the embodiments shown in figures 3 and 5, oscillating steep arm lappers are outlined as web laying device 14 or 45 respectively, and for the embodiment in figure 4, a basic drawing of a horizontal lapper is provided as web laying device 22 in the design of a carriage lapper.

Since the two partial webs that is to say the slower partial web 5 and the cross-fiber partial web 1 laid in zigzag shall be united to form one common complete web 4, they do not only have to be of the same width but have also to be brought together with the same position in cross direction and with the corresponding speed of the web length. In order to be able to fulfil this dimensional condition, in general certain process conditions apply to the web laying devices used to guarantee that the above mentioned geometric conditions can be fulfilled, i.e. the same width and the same speed of the cross-fiber partial web 1 and the slower partial web 5.

Namely, the partial layers to be laid in zigzag to form a cross-fiber partial web 1 have to be laid under such an angle α, the sine value of which corresponds to the value of a proper fraction in the form 1/n where n is an integer less than seven. In other words, the partial layers to be laid in zigzag to form the cross-fiber partial web 1 have to be laid alternatively under one of the angles α mentioned in the following:

30,0° ($\sin \alpha = 1/2$)

about 19,5° ($\sin \alpha = 1/3$)

about 14,5° ($\sin \alpha = 1/4$) or

about 11,5° ($\sin \alpha = 1/5$)

For this purpose, the faster partial web 2 has to be taken off from the web forming device with a speed v_2 which is by a corresponding integral multiple higher than the doffing speed v_1 of the slower partial web. Thus, the above mentioned ratio of the doffing speeds or the reciprocal v_2/v_1 respectively is preferably two, three, four or five. Despite their possibly varying absolute speed, the two doffers 11 and 12 running at different speeds have to run at a fix, adjustable speed ratio corresponding to one of the stated values. The higher the speed ratio v_2/v_1, the lower the possible angle α between the partial layers laid in zigzag within the cross-fiber partial web 1 and the more likely the fibers 3 of the original fleece are really oriented crosswise within the cross-fiber partial web 1. On the other hand, a speed ratio v_2/v_1 of the web doffers which is too

high not only causes problems when doffing the web but also when laying the cross-fiber partial web 1 in zigzag. A technically feasible upper limit seems to be reached at a speed ratio v_2/v_1 in the order of about 5 to 7. A further increase would only lead to more technical and operational problems and would, from the point of view of textile technology, not offer more advantages for the finished nonwoven.

By laying in zigzag the faster partial web 2 by means of a web laying device 14, 22 or 45 respectively (figures 3, 4 or 5) to form the cross-fiber partial web 1, a process-immanent redirection of the running direction of the web length by 90° takes place. On the other hand, the cross-fiber partial web 1 formed in this way and the slower partial web 5 shall be brought together with the same direction, the same position in cross direction and at the same speed. For this reason, the different embodiments of the production device provides for another web redirecting device 17, 28 or 43 respectively, which provides for this parallel run of the partial webs to be brought together. This aspect will be dealt with in detail below when describing the individual embodiments. At this point, it shall only be mentioned that the web redirecting device 17, 28 or 43 respectively of the different embodiments each are situated differently within the production device and/or are assigned to different partial webs. It is in this respect and in the resulting consequences, the embodiments in the figures 3, 4 and 5 differ from each other.

A component of the device and the process, which is essential to the invention, is the web redirecting device 17, 28 or 43 respectively, which is provided by all individual embodiments, even if with a different assignment. All embodiments have in common, that the web redirecting device 17, 28 or 43 respectively, independent of the fact to which of the partial webs it is assigned, in each case redirects the assigned partial web at right angles as to its running direction shown in the outline. Moreover, all embodiments have in common that the web redirecting device with regard to its part effecting the redirection, i.e. the web redirecting rod 18, 30 or 43 respectively - seen from above - is situated approximately at the same position as the effective part of the respective web laying device 14, 22 or 45 for the faster partial web and is staggered in height with regard to it.

In connection with the said same positioning of these two system components and the respective orientation values on the one hand it has to be said, that the laying rolls (number 25 in figure 4) of the web laying devices 14, 22, 45 describe a square when travelling back and forward. On the other hand, the web redirecting rod 18, 30 or 43 of the web redirecting devices 17, 28, 43 each are situated diagonally in a square of the same size. These two squares, the one of the web laying device on the one hand and the one of the web redirecting device on the other hand have to be - seen from above - at the same position.

After the slower partial web 5 and the cross-fiber partial web 1 have been brought together to form the complete web 4, the production device finally integrates a device 13 for bonding the complete web 4 to form a nonwoven, which is only shown in generalised form in figure 3. Here, in principle the complete range of known web bonding processes is possible. In this connection, the reader is referred again to the above mentioned textbook „Vliesstoffe", which deals in chapter 6 „Vliesverfestigung" (pages 269 - 399) with the known processes of web bonding and in particular with the stitch bonding of webs. In the following, bonding of the multilayer web to form a nonwoven is not dealt with in more detail, it shall only be mentioned, that a stitch bonding process where the stitch wales are oriented in longitudinal direction of the web length is the most advantageous both from the point of view of textile technology and with regard to the intended use of the nonwoven.

After having dealt so far with the correspondences of the different embodiments in the figures 3, 4 and 5, now the individual embodiments themselves shall be explained in more detail which - as mentioned above - differ mainly from each other by the type of assignment of the web redirecting device essential to the invention. In case of the production device shown in figure 3, the web redirecting device 17, represented in a simplified way only by the web redirecting rod 18, is assigned to the faster partial web and is functionally *preceding* the web laying device 14. Before reaching the web laying device 14,

which is also represented in a very simplified way and is shown as an oscillating steep arm lapper, the faster partial web 2 is „temporarily" brought into a direction at right angles to the working direction 7, from where it is laid to form the cross-fiber partial web 1, by which - in a process-immanent way - another redirection by 90° is effected. In this process, the faster partial web 2 or the cross-fiber partial web 1 respectively is redirected two times - seen from above - during its course, whereas these two redirections compensate each other after all. Seen from above, the running direction of the united complete web 4 corresponds to the working direction 7 of the web forming card 10; both directions 7 and 8 have the same alignment. By means of a web transport belt 15, the slower partial web 5 is transported over the web redirecting device 17 and the web laying device 14 situated below. The process of laying the slower partial web with the same position in cross direction and at the same speed v_1 on top of the cross-fiber partial web 1 which is carried by the web transport belt 16 is effected at a position, which is displaced in working direction from the web laying device; a pair of pressing rolls 19 compresses the partial webs before they are transported by means of the web transport belt 16 to the web bonding device 13.

In figure 4, only a central part of the production device is shown, i.e. the web formation itself and the doffing of the two partial webs 2 and 5 with different speeds v_1 and v_2 on the one hand and the device for bonding the complete web 4 to form

a nonwoven on the other hand are omitted in the representation of figure 4. The slower partial web 5 is carried by the web transport belt 20 straight through the production device, i.e. this device is also straight, which means that the working direction 7 of the web forming device and the direction of the subsequent treatment correspond to one another.

Also like in the embodiment according to figure 3, in the device according to figure 4 the web redirecting device 28 is assigned to the course of the faster partial web 2 or the cross-fiber partial web 1 respectively. But in contrast to figure 3, in the embodiment according to figure 4, the web redirecting device 28 is assigned to the *cross-fiber* partial web 1 and is functionally *succeeding* the web laying device. As for the rest, figure 4 shows the complete web redirecting device 28, even if restricted to those parts essential to the functioning; this will be dealt with below in more detail. Also the web laying device 22, designed as flat building horizontal lapper in the type of a carriage lapper, is shown more detailed in figure 4, even if only the elements essential to the functioning are represented. The faster partial web 2 is transported by means of a web transport belt 21 to the web laying device 22, where it is laid on a pair of intermediate transport belts staggered in height and vertically distant, i.e. not touching each other, a top carriage (belt 24) and a laying carriage (belt 24') with laying rolls 25, which move synchronously but in reverse motion in horizontal direction in the rhythm of the

zigzag laying. In this process, the faster partial web 2 (speed v_2) is laid in zigzag and with a width of the web length corresponding to the original width onto the transport belt 23 which is travelling at the slower speed v_1 and is situated at right angles to the transport belt 21 and the intermediate belts 24, 24'.

By laying the fleece in zigzag to form the cross-fiber partial web 1, a redirection by 90° of the partial web immanent to the process takes place. By means of the web redirecting device 28 which succeeds the web laying device 22, this redirection can be compensated by another redirection by 90°, and the original direction 7/8 can be adopted again. The web redirecting device 28 is situated above the web transport belt 20 for the slower partial web 5 and is arranged with its part that is essential for the redirection of the cross-fiber partial web, i.e. the web redirecting rod 30, at the same position (seen from above) as the web laying device 22, which, however, gets not quite clear from the perspective drawing in figure 4.

In order to bridge the height difference of the levels of delivery of the web laying device 22 on the one hand and the web redirecting device 28 on the other hand, the web transport belt 23 integrates a lifting section 26: By means of clever arrangement of redirecting and guiding rolls, the belt run of the web transport belt 23 is bent in L-shape and is led over to the steeply upward pointing lifting section. The section of the web

transport belt 23 effecting the transport, which carries the cross-fiber partial web leads over to the lifting section 26. To guarantee a secure transport of the cross-fiber partial web on this steep section, a supporting belt 27 guided in L-shape is provided which in the area of the lifting section 26 clings with a steeply guided part to the transporting section of the web transport belt 23. Thus, in the lifting section the cross fiber partial web is held between web transport belt 23 and the touching supporting belt 27 while being transported to the top. The upper leg of the L-shape supporting belt 27 is almost horizontally and is arranged above the web redirecting device 28. The transporting section of the web transport belt 23 of the lifting section 26 slightly extends into this almost horizontal leg of the supporting belt 27, so that the cross-fiber partial web which is transported to the top can be laid there. The cross-fiber partial web is then transported from the horizontal leg of the supporting belt to the guiding belt 32 of the web redirecting device 28.

The web redirecting device 28 shown in detail in figure 4 consists mainly of a driven endless guiding belt 32, which is guided in a rectangle via not rotating turning rods 29, 30. Neighbouring sections of the guiding belt which follow each other at each a turning rod, enclose with their lateral sides - seen from above - an at least approximate right angle, whereas the respective top and bottom sides of the guiding belt are on the whole arranged in parallel to each another. At a constant

belt run, such a guidance of a belt is only possible, if a sliding redirection takes place at the turning rods. Thus, the turning rods may not rotate. For practical reasons, the turning rods are pipes having a smooth and hardened surface.

The guiding belt 32 of the web redirecting device 28 is driven with the speed of the assigned partial web, which in the embodiment shown in figure 4 is effected by several pairs of drive shafts 31, one situated on this side of the guiding belt and the other on the other side of the guiding belt. In the embodiment according to figure 4, the required running speed of the guiding belt 32 is the - lower- speed v_1 of the cross-fiber partial web 1. At this point it shall already be mentioned, that also in the example according to figure 5, where the web redirecting device 43 is assigned to the slower partial web, the web redirecting device is driven at the lower speed v_1 of this partial web. Only in the embodiment according to figure 3, the web redirecting device 17 is assigned to the faster partial web 2 and thus has to be driven at the higher speed v_2 of this partial web, which could possibly prove to be a certain disadvantage if no anti-friction devices are provided at the turning rods.

In the area enclosed by the guiding belt, the turning rods 29, 30 can be equipped with several grid-like distributed anti-friction devices. These can be balls embedded in the outside of the turning rods, which are freely movable but are se-

curely held, allowing for the guiding belt to roll over. Another possibility to decrease friction is to build up an overall air cushion in the contact area between the turning rod 29, 30 and the guiding belt 32. In this case, grid-like distributed air discharge openings have to be provided in the area enclosed by the guiding belt, which are permanently supplied in excess with compressed air from the inside of the pipe-shaped turning rods. In this way, the guiding belt floats so to speak on a compressed air film which at the same time takes any frictional heat. Moreover, the risk of electrostatic charge of the guiding belt would be lower, in particular if the compressed air would be well moistened. Thanks to the compressed air film, it would be able to guide the guiding belt 32 over the turning rods without resistance, but this would require a certain power for the generation of compressed air which, however, could easily be accepted.

Of the four turning rods 29, 30, which are necessary to guide the guiding belt 32 in a rectangle and which are situated at the "corners" of the rectangle, one turning rod labelled in figure 4 with the number 30 plays a special role. Only the two sections of the guiding belt 32 coming together at the one turning rod (hereinafter called web redirecting rod 30) actually touch the cross-fiber partial web to be redirected. This web redirecting rod 30 is the only one to redirect the cross-fiber partial web 1. The other three turning rods only serve to guide the guiding belt in a closed rectangle. Moreover, the

special web redirecting rod 30 is - seen from above - situated at approximately the same position as web laying device 22 and is arranged above it.

In addition to the redirection of the partial web, the web redirecting device essential to the invention has at least in the embodiment according to figure 4 also the task to bring about an exact correspondence of the two partial webs to be united with regard to their widths. For this purpose, at least one of the turning rods 29, 30, which guide the endless guiding belt, which are not rotating and which are situated in parallel to the plane of the adjacent sections of the belt, is pivoted to act as a belt run correction and is equipped with a corresponding swivel drive. Because of the web redirecting rod 30 being directly situated at the point where the two partial webs 1 and 5 come together, it would be best suited to effect the correction of the belt run in so far as it would enable a positioning of the belt in cross direction by means of an automatic control system with the lowest time delay between the intervention of the automatic control system and the new position of the belt run. Possibly, it is practical to also pivot the turning rod diagonally opposing the web redirecting rod 30 in the same way and to equip it with a swivel drive. A synchronous but opposite swivelling of the two pivoted rods would result in a regular belt tension over the whole width of the guiding belt despite the intervention of the automatic control system. Besides, this would result in an overall more stable belt run,

i.e. the risk of the belt run control getting unstable due to the intervention of the automatic control system is decreasing.

In order to be able to properly operate the guiding belt of the web redirecting device with regard to a positioning of the belt in cross direction by means of an automatic control system, the guiding belt has always to be held under a certain belt tension regardless of thermal or age-dependent extensions or shrinkages. For this purpose, two neighbouring turning rods of the web redirecting device 28 situated in parallel to the plane of the adjacent sections of the guiding belt run on bearings to be moveable and are equipped with the respective shifting drive for tensioning the guiding belt 32. For practical purposes, the two turning rods movable to this effect can be moved in parallel to the two opposing sides of the rectangle built by the two turning rods. With the movability realised in such a way, no angle changes are caused within the rectangle when tensioning and thus there is no effect on the position of the belt in cross direction.

For the sake of completeness, a variant has to be mentioned in connection with the embodiment shown in figure 4, where - similar to the embodiments according to figures 3 and 5 - the cross-fiber partial web 1 is located at the bottom and the slower partial web 5 is located at the top of the complete web formed by the two partial webs 1 and 5. For this purpose, on the one hand the web transport belt 20, which carries the

slower partial web 5, would have to be guided over the web re-directing device 28 and would have to be led to a uniting point on a separate web transport belt situated at the back of the line. On the other hand, just this separate web transport belt, which is oriented according to the direction 8 of subsequent treatment would have to be installed, on which the cross-fiber partial web 1 redirected to the direction of subsequent treatment can be laid by the web redirecting device 28.

The top side arrangement of the slower partial web the fibers of which are oriented in longitudinal direction offers structural and operational advantages for the subsequent stitch bonding of the complete web to form a nonwoven using certain stitch bonding processes.

In the third embodiment of a production device shown in parts and again very simplified in figure 5, the web redirecting device only represented by its web redirecting rod 43 is assigned to the slower web. Instead of the web redirecting rod 43 one has to imagine a web redirecting device according to the example in figure 4 or according to the example in figure 6. The slower partial web 5 redirected at the web redirecting rod 43 is laid onto the web transport belt 44, which carries it further in direction 8. Also the cross-fiber partial web 1 is redirected immanent to the process to the direction 8 of the subsequent treatment which is at right angles to the working direction 7 of the web forming device by laying the faster par-

tial web 2 in zigzag to form the cross-fiber partial web 1. The web laying device 45 lays the zigzag partial layers of the cross-fiber partial web 1 onto the lower web transport belt 46, which also travels in parallel to the direction 8 of subsequent treatment. Also in this case, the web redirecting rod 43 and the web laying device 45 are again arranged staggered in height to one another but - seen from above - at the same position. The lower partial web 5 transported on an inclining section by the upper web transport belt 44 is united with the cross-fiber partial web 1 laid onto the lower web transport belt 46 to form a double-layer complete web 4 which subsequently can be bonded to form a nonwoven. In the embodiment according to figure 5, the web transport belt 44 can also be used to provide for the slower partial web 5 and the cross-fiber partial web 1 having the same position in cross direction, when the corresponding web edge detectors and controllable belt guiding rolls are integrated into the course of the belt.

The production device outlined in figure 5 is all in all arranged at an angle - in contrast to the straight devices according to figures 3 and 4 ; the working direction 7 of the web forming card together with the direction 8 of subsequent treatment enclose a right angle.

The web redirecting device 28 shown in figure 4, which has also to be included in the calculations of the devices according to figures 3 or 5, takes up relatively much space. One

can assume, that the rectangle built by the guiding belt 32 which is almost square has a side length of about two and a half times the working width of the web forming card. Therefore, it is practical to design the web redirecting device in elevated position so that it can be suspended from the ceiling construction of the shop or from a supporting structure located above the production line without taking up valuable space at the shop floor.

In order to decrease the space requirement of the web redirecting device, in the embodiment shown in figure 6 the guiding belt 51 of the web redirecting device 50 is arranged on two different levels at a distance from each other to use a minimum of space. Namely at the section of the guiding belt coming from the web redirecting rod 54 and at the section which is parallel and opposed in the same horizontal plane, a turning roll 52, 52' surrounded by 180° by each a section is provided. The diameter of these redirecting rolls determines the distance of the two levels of the guiding belt 51. Apart from the low space requirement, the web redirecting device 50 according to figure 6 offers also the advantage of a compact construction. This means, that the supporting structure of the individual components such as rolls, turning rods and the like is more compact and more rigid. Of the four turning rods 54, 55, two at a time lie in the top view at least nearly congruent but staggered in height by approximately the roll diameter, i.e. they are close together. As in this case two opposing sections of the guiding

belt strongly surround the redirecting rolls 52, 52′, the thing to do would be to use at least one of them to drive the guiding belt 51 of the web redirecting device and to equip it with a respective swivel drive. If both turning rolls 52, 52′ are used to drive the guiding belt, it should be considered that both turning rolls have to rotate at the same speed but in the opposite direction. For the synchronisation of the two turning rolls to be driven, in this case a reversing gear gearing level between the two turning rolls would be useful. In addition to serve as drive, the turning rolls could also be used to tension the guiding belt. For this purpose, they would have to run on bearings to be linearly moveable in the direction of the sections of the guiding belt surrounding them and have to be equipped with the respective shifting drive.

For the sake of completeness it has to be mentioned, that in connection with the redirecting device 50 shown in figure 6, the guiding belt 51 of the web redirecting device may also be arranged on two different planes which are inclined to each other instead of being arranged in parallel planes as shown in the embodiment 50 of figure 6 or instead of being arranged in a common plane as shown in the embodiment 28 of figure 4. Inclining the two planes to each other would reduce the overall space needed for the redirecting device too. The sections of the guiding belt 51 coming from the turning roll 52, going around the two turning rods 55 and running again to the turning roll 52' are arranged in figure 6 in an upper level. Theses three

sections of the guiding belt 51 form one half of the whole guiding belt 51 and - in any case - are to be arranged in one plane roughly (there is a small distance between the middle section at the one hand and the two other sections belonging to the turning rolls 52, 52' on the other which can be out of regard in this respect). There is quite a similar arrangement of sections in a lower level going around the turning rods 54 and 55. This latter triple of belt sections has in any case to be arranged almost in one plane too. But the mentioned two triples of belt sections may be arranged in planes being inclined to each other so that the turning rolls 52 and 52' are surrounded by the guiding belt only an angle that is less than 180° for instance by 90° or by 135°.

For the sake of completeness it has to be mentioned, that in connection with the three-layer web 6 shown in figure 2, a web forming card with three different doffers or two different web forming cards connected in tandem one after the other, which together provide the three web doffers, would be required. With such a web forming device, three separate partial webs 5′, 2, 5′′ are formed in the same web forming process with the same raw fibers or raw fiber blend respectively, which are each taken off at the three different, staggered web doffers. The web doffer in the middle is driven by the several times higher speed v_2, whereas the two other web doffers rotate at a lower speed (v_1). At these two doffers, the two slower partial webs 5′, 5′′ are taken from the web forming process. The faster

partial web 2 taken off at the faster web doffer is laid in zigzag to form the cross-fiber partial web 1, for which a redirection immanent to the process takes place. Afterwards, also in this case the cross-fiber partial web 1 and the slower partial webs 5', 5'' are synchronised, for which the embodiments shown in the figures 3, 4 or 5 could serve as an example. Then, the three partial webs 5', 1 and 5'' are joined at the same speed v_1, with the same direction and the same position in cross direction to a three-layer complete web 6, which finally can be bonded to form a nonwoven.